By Ed Lawrence, WA5SWD

Amateurs often speak of “Standing Wave Ratio”, SWR for short, when talking about an antenna. They may state the useful antenna bandwidth as being between two frequency limits, lower than 2:1 SWR. In the simplest terms, SWR means the “badness” of whatever is the load in question, usually (but not always) an antenna. SWR is always referred to a specific load resistance, such as 50 ohms as we usually use 50 ohm line.

1:1 is perfect and theoretically unobtainable, but we can get close.

1.1:1 is almost perfect, thus it has low “badness”.

1.5:1 is good enough for almost every purpose, and is low to medium “badness”.

2:1 is getting into the questionable zone. The “badness” value is getting high enough to cause problems in some cases.

3:1 is the generally accepted limit for “badness”. 3:1 SWR will cause problems in many cases.

WHAT DOES A BAD SWR DO TO MY RADIO?

Assuming you are using a modern solid state transceiver, not much. For the older rigs with tubes as finals, maybe nothing. If you can tune up the output stage correctly, no real effect! If the SWR is less than 1.5:1, the effects are minimal. If the SWR is greater than 3:1, then your solid state transmitter may reduce the power out to keep from blowing your finals. See the manual that came with your transmitter. Generally, the amount of receiver sensitivity reduction will not be an issue. You transmitter output signal will suffer as much as a 50% loss with a 3:1 SWR due to the mismatch. This is about one S unit.

HOW DO SWR METERS WORK, AND WHAT KIND OF ERRORS DO THEY CAUSE?

SWR Meters measure the forward power TO the load and the reflected power FROM the load. Most meters, while useful, fall far short of laboratory standards. Basically, the RF is sampled by a dual directional coupler. One port of the coupler has an output proportional to the forward RF, the other, the reflected RF.

Each of these is rectified to make a DC voltage that represents the FORWARD and REFLECTED signal. The meter face is calibrated to show the SWR after you have set the FORWARD power to full scale.

If you open up one of the inexpensive CB SWR bridges you will see few parts. They are made to produce an indication of SWR and a profit for the manufacturer. Most are still useful through 2 meters but not generally 440 MHz.

Errors are induced if the impedance of the pickup line does not match the transmission line it is inserted into. If the pickup line is shorter than 1/8 wavelength these errors are generally small.

The directional coupler (pickup) has a quality called directivity. This is a measure of how well it separates out the forward and reflected signals. The higher the directivity, measured in dB, the more nearly perfect the coupler is. That inexpensive CB SWR bridge has poor directivity. The effects of low directivity cause low precision of the SWR measurement. As Amateur Radio Operators we can accept this imprecision since we still get a useful indication of SWR.

The last major error comes from the diode detectors in the SWR meter. Diodes take a small voltage just to turn on. This tends to subtract a bit off the bottom of each of the FORWARD and REFLECTED meter indications. This makes the SWR appear better than it really is. The moral of this story is to make your final SWR measurements at the highest power output you have available if you want the truest indication.

WHERE SHOULD I PUT THE SWR BRIDGE IN THE TRANSMISSION LINE?

While operating your station, where you can read it! The proper length of the feedline is the minimum length to reach from the rig to the antenna. If you are testing an antenna, put the SWR Meter as close to the antenna as possible.

You will hear stories about “Magic” line lengths you should use, such as integer multiples of a half wavelength, or that you can match the antenna by trimming the feedline length. This, to be polite, is hogwash.

SWR, on a lossless line, does not vary along the line. It is a measure of how well the antenna matches the feedline, nothing else. Effects that make this appear NOT to be true can be attributed to a poor SWR meter OR RF on the outside of the coax where it is not supposed to be.

Your main use of an SWR Meter is to show you that the antenna is still functioning properly. The exact value is not critical. If the SWR suddenly goes high, you have a problem that you must fix.

Now I can just hear the mumbling from some of the old-timers. Demonstrations, either mathematical or practical, of how this long lossy line can be either open or shorted and still show 1:1. Question: How efficient is your station with that lossy line? You will not use it in the real world, and that is the point. Next question: Have you ever seen this happen in the real world? I haven’t.

HOW DOES LINE LOSS AFFECT THE SWR INDICATION?

It lowers it, making the load look better. Well, as far as the transmitter is concerned, it IS better! You lose both transmitted and received signal strength so you really want low loss line and a well matched antenna, but lossy line DOES tend to protect your transmitters finals.

THE BOTTOM LINE

Use the lowest loss feedline you can afford. Tune your antenna to the lowest SWR with the

antenna in its operating position with the best SWR meter you can buy or borrow.

Use an SWR Meter at your operating location to monitor the health of your antenna system.

Go learn more about how SWR is calculated. Any ARRL Handbook for The Radio Amateur will do. While there you should also gain a good understanding of Reflection Coefficient. It is a more useful concept.

After you have learned to think in terms of Reflection Coefficient you will be ready to start learning about Smith Charts. They are a truly neat tool and expand your ability to match electronic antennas and amplifiers. They look like a web spun by an artistic spider but they allow a person to graphically solve complex impedance problems with a compass and a ruler!

73

Ed